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ABSTRACT

The impact of educational technologies on various curricula and on projected curricula reform at the University of New South Wales is discussed. It is argued that the existence and use of such technologies can reach beyond being tools that simply provide assistance in instruction, and can often have considerable effect on the curriculum itself. Most of the examples are drawn from engineering education and are concentrated in large part on the educational uses of interactive computing. The term 'educational technology' embraces commonplace instructional aids also. The use of a Wang desk-top minicomputer in an undergraduate engineering laboratory and resulting efforts to employ the minicomputer to improve the teaching effectiveness of laboratory experiments are described. The innovative use of automated marking (through optical scanning of appropriate answer sheets) and use of computer marking of papers incorporating a variant of the standard multiple-choice format are also discussed. Innovation in educational technology can also affect the content of a course. The introduction and increasing availability of on-line remote computing facilities, in which students participate in dynamic interaction with models of engineering systems, can open up new areas of syllabus and new sets of course objectives. (Se)

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SOME EFFECTS OF EDUCATIONAL TECHNOLOGY ON CURRICULUM REFORM: EXAMPLES FROM THE UNIVERSITY OF NEW SOUTH WALES

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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This Research and Development Paper is based on a public lecture given to the Darling Downs Centre for Advanced Education in February 1975. The paper elaborates further on some of the propositions made at that lecture, and includes some more recent examples from the University of New South Wales which are relevant to the theme of that talk.

D. Nagin
October 1976

The Tertiary Education Research Centre at the University of New South Wales has been established to improve teaching and learning within the university. As part of that function personnel within the Centre are often involved in assisting the teaching staff in the effective use of various educational technologies and in the evaluation of their application in specific situations.

Such educational technologies - and here I am employing the common, if narrow, definition of educational technologies as the 'things' or hardware of instruction - are generally looked on as tools which increase, to a greater or lesser degree, the effectiveness or efficiency of instruction. Over the last few years, however, it has become apparent that the utilisation of educational technologies often have a much more penetrative effect, and that many of our assumptions about their role in the teaching and learning process do not take sufficient account of their special impact on the course in which they are to be introduced.

This paper presents evidence, from examples at the University of New South Wales, of the impact of educational technologies on various curricula, and on projected curriculum reform. It is argued here that the existence and use of such technologies can reach beyond beings tools which simply provide assistance in instruction, and can often, without our conscious foreknowledge, have considerable effect on the curriculum itself.

Most of the examples and illustrations are drawn from engineering - my own activities and research in the application of educational technologies being within engineering education - and are concentrated in large part on the educational uses of interactive computing. Although 'educational technology' is perhaps pretentious sounding, it should be emphasised that the term also embraces such commonplace instructional aids as chalk and blackboard.

Of recent origin as an instructional tool, interactive computing provisions are, I believe, the most dramatic and significant of such innovations. In describing the evaluation of computer use for teaching purposes, Sir Eric Ashby[1] referred, ten years ago, to this as the 'Fourth

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1. See Chapter 3, Eric Ashby, "Adapting Universities to a Technological Society", Jossey-Bass, San Francisco, 1974. This chapter, "Technology in Education", was originally presented in 1966 as the Joseph Wunsch Lecture, Israel Institute of Technology, Haifa.

Devolution' in instructional technology and saw it as becoming central to instruction in tertiary education. Many of us now are similarly convinced of the power and the capability of today's educational technology, especially that of on-line interactive computing. What to us seems arresting and puzzli is that few of us see evidence, here in 1976, of the successful applications of educational technologies in our institutes and universities.

Why is this so?

Let me approach this question by, first of all, advancing two propositions for your consideration.

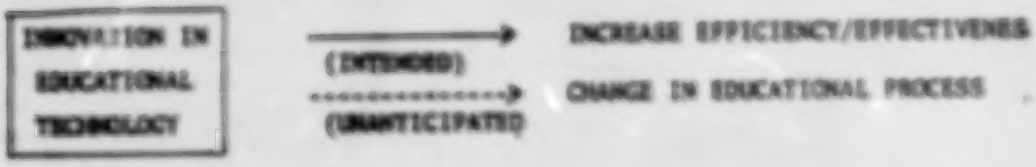
(1) *Innovations in educational technology can often act, in themselves, as agents of change in the curriculum; can not only cause radical change in the process by which learning occurs (and in ways often quite unanticipated), but can often effect pervasive changes in content - i.e. syllabus.*

A second proposition:

(2) *That as teachers and curriculum developers, we should look at educational technology from the point of view of how it can be used to realise new objectives, new learning experiences unattainable by traditional instructional methods; and that we deliberately set about employing new educational technologies to actively and consciously transform the curriculum.*

Let us look further at an important aspect of the first proposition 'That the adoption of a new educational technology (and again I am simply referring to the 'hardware' of instruction) often results in unanticipated changes in the educational process for which it is designed to serve.'

Diagram 1



To instance a few examples:

(i) In 1975 the availability of a Wang desk-top minicomputer in an undergraduate engineering laboratory prompted two of the Engineering faculty involved in teaching experimental engineering to investigate ways of employing the minicomputer to improve the teaching effectiveness of laboratory experiments. Initially, it was anticipated that the use of a minicomputer would increase the efficiency of students' laboratory work by reducing the time required by students in data reduction and analysis - these aspects of experimentation being seen as essentially peripheral to the major goals of laboratory work in an experimental engineering course. Yet, when we came to observe students' laboratory work and inspect their reports it was apparent that, for a number of experiments in this course, the major part of these students' intellectual efforts were concerned with this very aspect - data reduction and analysis. The essential aspects of experimentation (as the investigators saw them) - of knowing what to measure, how to measure, and in general how to plan and validate experimental procedures - were, for the most part, not seen by students as important or problematic, since it had been usual practice for staff to provide procedural instructions and personal guidance for these.

The innovation of employing a minicomputer for analysis (and instant feedback of transformed data) provided the stimulus and capability for re-directing attention to experimentation itself, whilst the students were working in the laboratory.

A pilot study of students' laboratory performance in 1975, and an evaluation of their reactions to the changed format indicated that behaviour was indeed changed by the innovation (and changed requirements) and that students were highly conscious of the particular laboratory exercise's essential difference from other experiments in the course (Nagin, Raizes, Sivyer, 1976). On the basis of the pilot study the laboratory course in experimental engineering in 1976 was re-designed to focus on the previously underemphasised skills of experimentation.

In retrospect, we are impressed that what started out as an exploration of the use of a new educational technology in increasing efficiency did in fact lead to a review, and change of emphasis, in the goals of the teaching process. Not only did we not originally

anticipate this outcome, but we found a certain irony that the use of the minicomputer- which prompted the changes - is not now seen by us as essential to the new approach in experimentation.

(2) A second example: The use of automated marking (through optical scanning of appropriate answer sheets) was seen as a desirable innovation at the University of New South Wales because it not only provided rapid and inexpensive processing for assessment purposes, but also provided the means for a useful diagnostic function (by allowing rapid feedback of achievement to students) at times other than near the end of the course.

As many students have discovered, however, the use of this technology for continuous assessment can often result in "more assessment". Also, assessments of this kind easily lend themselves to influencing the direction of teaching and learning towards being able to select a correct response from a specified range of alternatives. Of course this need not necessarily result, and even so, it may well be a desired outcome which articulates with some of the goals of a particular course of instruction. But one suspects that in very many instances lecturers who employ this technology are quite unaware that its adoption has actually altered students' learning strategies and behaviour.

(3) And third, a further example involving the use of the optical scanner: A colleague in the fuel technology department decided to use computer marking of quizzes incorporating a variant of the standard multiple-choice format. The variant he used was to assign differential 'weightings' to the various distractors according to the 'degree of correctness' of each as solutions to fuel technology problems. (The 'weights' used were typically 3, 2, 1 and 0.)

He had intended to use this technique to increase the *reliability* of the test (since they, in theory, provide more information than that provided by a standard format). The upshot was that increased reliability was marginal, but that students now began to ask *why* one answer was weighted '3', another '2', another '1' and so on. He now consciously uses this technique as a *teaching device* rather than primarily as an assessment.

Many other examples could be instanced to support the assertion. Though I believe it unexceptionable, it would appear a too little appreciated assertion that an educational technology does not simply act to improve the "efficiency" or "effectiveness" of the teaching-learning processes, but that it reaches beyond to influence the character and substance of the processes themselves. If we think of curriculum in the wider sense - as embodying all the learning experiences which are organised and planned as part of a course of instruction - it is quite justifiable to claim that innovations in educational technology exert their own impetus for curriculum change.

But let us look at the more contentious issue of innovation in educational technology as affecting the CONTENT, or syllabus of a course. I will start with what may be regarded as a truism appearing to you as perhaps odd to advance here:

> *Regardless of their desirability, those skills and competencies which cannot be successfully taught or adequately developed in a course of instruction have no place in the objectives of that course.*

Of course this is obvious. We cannot expect students to achieve what is manifestly not achievable. But there are reasons for bringing this to attention here. Let me illustrate with respect to engineering education.

In recent years a rhetoric about engineering education curricula has been making itself heard. It is a rhetoric that calls for engineering education to become "real-problem oriented, instead of knowledge-discipline oriented" (c.f. Dixon and Nelson, 1973 : 39); that points to the need for teaching for "physical understanding" (Hammond, 1969 : 446); that says that one best learns about engineering by *doing* engineering (c.f. Forrester, 1970). For some time engineering academics in Australia have been saying similar things, using slogans such as "put engineering back into engineering courses" and "more hands-on experience in earlier years". Whatever the meaning behind such slogans, they are, I believe, indicative of a ground swell of discontent with present curricula, and indeed over the last year or so there have been stirrings - at the University of N.S.W. and elsewhere - towards substantial curriculum reforms. It is my opinion that the views as expressed above have been little acted upon because no *realisable* way has been developed for the successful implementation and integration of this new perspective. Until recently the chance of achieving many of these desired capabilities of engineering graduates has been seen as a fond hope rather than a practical

possibility in undergraduate education.

Of particular relevance to this felt need has been the introduction and increasing availability of on-line remote computing facilities (in which students participate in dynamic interaction with models of engineering systems). These have the potential to open up new areas of syllabus, new sets of course objectives not included in traditional engineering curricula.

The "Missing Curriculum"

It is my belief that this comparatively new and most sophisticated of educational technologies has the potential to play an instrumental role in bringing into an engineering course what I call the "missing curriculum".

In engineering there is an increasing awareness of shortcomings in the curriculum: What is considered the most important of instructional objectives are not specified; what is regarded as the most desirable of graduate capabilities are never attempted. And this has come about, not because they are matters of "process" rather than "content", nor because they are "best left unstated" or are incapable of precise behavioural definition, but precisely because they are considered *untouchable* in the present context of our course provisions.

Dwyer, in a recent article in the International Journal of Man-Machine Studies, gives hint of the appropriate role of educational technologies when he suggests that we should evaluate their effectiveness, not by increased gains in learning in those areas usually achieved by traditional techniques, but by the extent to which they "fill in glaring gaps in a system (of instruction)" (1974, p 131).

How real is the concept of the "missing curriculum" for engineering courses in the University of New South Wales? I think it quite real, to judge from the direction of current curriculum changes; from present activities directed at course re-construction; and from recent expressions about what should be done if instruction is to be made successful. Listed below are some of the areas which make up this "missing curriculum" in the eyes of a number of engineering academics. Those which are instanced here are general enough to each relate to most areas of engineering:

Examples

(i) "Order of magnitude" understanding of functional relationships (especially those of a non-linear kind) through the observations

and manipulation of engineering systems.

(ii) Solution of "real-world" problems, ill-formulated and open-ended questions.

(iii) Acquaintance with limitations and discontinuities of parametric variations in physical systems - especially those not easily predicted by analysis of mathematical models.

(iv) Design of complex systems and optimisation procedures, including economic analyses.

(v) Validation of mathematical models and algorithms against relevant data.

All of these desiderata require in part, if not in toto, student use of on-line interactive computing. This is not just because of the difficulty of, or time taken in, computation (for which batch-processing computing would be appropriate) but because these instances demand "convergence" processes; they require repeated manipulations of parameters of an appropriate model, manipulations which are guided by immediate feedback of the consequences of decisions or variations made.

In considering some specific cases of how interactive computing has brought the "missing curriculum" into engineering courses it is contended that:

> *The introduction and utilisation of on-line remote computing facilities have already affected, and will increasingly exercise influence over, both content and process in engineering curricula.*

The first case is drawn from Mechanical and Industrial Engineering. For several years the Engineering faculty at the University of New South Wales has provided, for students, limited access to on-line interactive computing for undergraduate instruction. In 1974, the installation at the university of a new computing system (Cyber 70) allowed expansion of these facilities, with approximately 40 on-line remote terminals being situated within Engineering alone. Earlier effort, pioneered by Professor De Vahl Davis, was directed at modelling systems and experiments whose physical counterparts were either beyond university resources, or whose scaled-down laboratory-experiment models did not reproduce the performances and characteristics of full-scale systems: e.g. large gas turbines give efficiencies substantially

larger than equivalent laboratory models; a small heat exchanger does not permit the variation in materials and fluid which occur in practice. Thus it was felt that many laboratory experiments were divorced from "real" engineering systems.

Through 1971 and 1972 programs were developed, written in APL, which modelled a number of different engineering systems. These included simulations of the following:-

Aircraft performance
Parallel flow heat exchangers
Cri'lage design (ship construction)
Aircraft vibration
Thermodynamic performance of a refrigeration compressor
Kinematic and dynamic characteristics of mechanisms
Pipe flow in reticulation systems

In 1973 an approach was made to the Tertiary Education Research Centre to assist in the improvement of the educational features of these programs, and to evaluate their learning outcomes. For 1973, one of these - the "pipe-flow" exercise - was selected. Apart from suggesting changes to the feedback procedures in the program, and measuring learning outcomes, attention was directed towards the relationship between what was being attempted by these exercises and the curriculum (including traditional performance requirements). The results of this study have been reported elsewhere (Reizes et al, 1974) but the following remarks may be apposite here.

The "Head-loss" section of the course (to which the "pipe-flow" exercise related) was designed to provide understanding - at both the analytic and functional level - of flow through pipe networks such as may exist in reticulation schemes. It has been found, over the years, that the central traditional task, successful manipulation of the "Head-loss" equations, was not achieved by the majority of students.

This was understood to be the case because, as expressed in the Reizes paper (evaluating the 1973 experiment):

> "Given the time constraints within which second year students organise their work, it is most unlikely that they can acquire sufficient experience, through exercises, to develop an adequate "feel" for making reasonable estimates for the various parameters involved

in "Head-Loss" problems." (Reises et al, 1974).

It was patently obvious to us that under conventional forms of instruction, students were not developing a functional understanding of pipe-flow systems. Yet, to the lecturers responsible for the course, "understanding" of pipe-flow would require all three of the following:

To enumerate:

(i) analysis of pipe-flow - calculation of outputs through the elaboration and manipulation of a mathematical model.

(ii) appreciation of constraints operating in real engineering situations; practical limitations of parameters such as size and materials.

(iii) appreciation of design possibilities through intersection of (i) and (ii), i.e. an understanding of "working systems" and the relationships operating between parameters.

It is worth noting that only the *first* of these desiderata is attempted in conventional instruction. The other two do not figure in the curriculum because, within the context of conventional provisions, they are not learnable. In the past, such lacunae in instruction have been rationalised as properly belonging to work experience after graduation. To quote Reises again:

> e.g. "One approach, perhaps a traditional, academic one, is that understanding can be achieved through thorough analysis of the mathematical model, that design constraints - e.g. pipe size - are technical details which properly belong to 'job experience'. It has been our experience, however, that successful manipulation of equations does not in itself, produce understanding of what is being modelled in the physical system. We may foreshadow some of our findings reported later, which suggest that such successful manipulations are often quite divorced from any real comprehension of the effect of varying certain parameters in the system." (Reises et al, 1974:139)

Let me turn to a second example. This refers to moves in engineering at the University of N.S.W. to re-structure present curricula.

Several schools in engineering have established, in the last few years, education committees to explore curricular change. The holding of "out-of-town" residential conferences (e.g. Faculty of Engineering conference at Leura) provided an impetus for the establishment of these school committees.

Although these conferences crystallised staff (and student) opinion on a wide range of issues, the issue of course reform was seen as paramount. For example, at the Electrical Engineering conference responses of academic staff indicated that the "need for curriculum reform" was by far the most common source of concern about educational activities.

Some areas in which consensus has already crystallised include:

(i) reduction of detail in syllabuses; reduction in formal contact hours, with encouragement to integrate as far as possible 'core' subjects

(ii) reduction in the "science" emphasis of the first year, and introduction of "engineering type" courses in that year

(iii) more experience in "doing engineering" (e.g. projects, "hands-on" experience) to produce increased familiarity with, and understanding of, real engineering systems.

Discussion within the School of Mechanical and Industrial Engineering Education Committee centred on similar considerations, but here the reference to the role of interactive computing was more specific. This can be seen in the following extract which argues for a move away from orthodox "engineering science" and towards increased involvement in interactive computing. To quote from a document prepared for that committee:

> "The greatest potential of computers is their capability for the simulation of complex interacting systems. Everything an engineer does is concerned in some way with society and the environment. Computer simulation of the system enables the interactive nature of engineering consequences to be investigated. Such studies enable efficiency to be improved and possible problem areas to be highlighted for further

consideration. In this way engineers can be more effective in "controlling the forces of nature for the benefit of mankind"." (Svensson, 1974, p. 3)

Since that time there has been considerable activity in course-reconstructions. Those changes that have been effected or decided on, and their direction indicate, I believe, a trend away from "engineering science" as traditionally conceived, and towards such activities as problem identification, modelling, decision-making - activities for which on-line interactive computing is more relevant.

Indeed, the very appreciation of the potential of on-line computing as a learning tool, the consideration of their possibilities alters our perceptions of how curricula can be organised, and of how engineering education should proceed.

I think there is no need to further elaborate with more examples. Let me return to the second proposition for today's talk.

Namely,

> "That we *look at educational technology from a view of how it can be applied to achieve new objectives, new learning experiences not attainable by traditional instruction.*"

I shall give some instances from the University of New South Wales which indicate, I believe, the fruitfulness of this approach.

The first example relates to the application of television for instructional purposes. Initial TV applications involved use of CCTV for the purpose of efficient mass-communication of lecture material. Results over the years could not be called spectacularly successful. Cost savings and 'effort' efficiency were dubious. Also, many of the student viewers responded negatively to the innovation - seeing them as having all the faults and none of the virtues of traditional 'live' lectures.

But VTR - video tape-recording - has opened up new learning experiences. Many of you are aware, of course, of micro-teaching, in which the apprentice teacher is confronted with a portrayal of his own behaviour, and the immediate consequences of that behaviour.

At the University of New South Wales VTR equipment is also being used for, what can perhaps best be described as "role-playing". Students in the faculties of e.g., Law, Medicine, are involved in simulating situations within, e.g., courts of law; doctor-patient encounters; client-solicitor transactions. These are then analysed in detail, often immediately after recording on videotape. The technique has proved particularly successful in providing understanding for the participant of his own behaviour in such settings, and has opened up hitherto unexplored learning experiences.

A last example relates to the use of automated techniques for marking student quizzes and examinations. An example of its use has been given earlier in today's talk. But to justify the use of machine-scorable test formats on the sole consideration of "efficiency" of marking does, in my opinion, court trouble. In such instances, accusations of "trivialization of learning" may well stick. At the University of New South Wales academics who wish to use the services of the Education Testing Centre's "optical scanner" for quizzes are asked to provide the Centre with sufficient information to enable the computer to provide, *for each student*, not only his result, but also a diagnostic summary indicating, e.g. information sources (book and page references) guiding student reading in order to overcome weaknesses in the testee's learning (Dunstan, 1973).

CONCLUDING REMARKS

I think these examples sufficient to illustrate the point that the opportunities to employ educational technology in ways which go beyond "improvement" or "efficiency", are manifold; that these new tools can be and are being used to extend learning experiences - to, in effect, change the curriculum.

In 1976 we have had access to these instructional tools - and I am thinking particularly of interactive computing facilities - for some years now. Yet there is little evidence that they have had the impact predicted for these new tools - certainly nothing like that indicated by the Carnegie Commission's study of the instructional uses of computers (Levien, 1972), in which 'computing' was seen as the most significant revolution in instruction since writing.

It can also be observed that the 'less sophisticated' instructional media are similarly under-used in our institutions - especially in the ways suggested in this paper. There are a number of reasons why academics

have been reluctant to utilize the resources available to them, and I would like to briefly list what some of these might be:

(i) lack of training in the use of instructional aids, and associated with this

(ii) lack of 'models' of their successful use in the teaching department

(iii) organization and preparation time required

(iv) the necessity of relying on 'others' - e.g. equipment is often not entirely under each individual teacher's control

and finally,

(v) a lack of appreciation of the 'potential' of the instructional technology available.

To this final point, many academics express (and correctly so, in my opinion) a doubt as to the increased effectiveness of using these new tools. Studies (witness CCTV) have often proved inconclusive, or point to marginal increases in learning efficiency.

But it is my hope that teachers will look at educational technology from a different perspective, that they will come to appreciate that these innovations in instruction can be used to do NEW things, to achieve new instructional goals hitherto not achievable - in short to allow attainment of the "missing curriculum". The concept of the "missing curriculum" has proved significant enough to engineering, and I venture to say, real and significant in other areas of learning and endeavour.

Works Cited

Ashby, E. Adapting Universities to a Technological Society. Jossey-Bass, San Francisco, 1974.

De Vahl Davis, G. and Holmes, W.N. The Use of APL in Engineering Education. Systems Development Institute Monograph. Form No. SKI-0005, Canberra, August, 1971.

Dixon, J.R. and Nelson, C.W. Practice-directed engineering education. Engineering Education, 1973, 64, 39-42.

Dunstan, M. Feedback to Lecturers and Students. Research and Development Paper, No. 28, T.E.R.C., U.N.S.W., 1973.

Dwyer, T.A. Heuristic strategies for using computers to enrich education. Inter. J. of Man-Machine Studies, 1974, 6, 137-154.

Forrester, J. Engineering Education and practice in the year 2000. Engineering Education, 1970, 60, 974-979.

Gagne, R.M. Educational Technology and the learning process. Educational Researcher, 1974, 3, 3-8.

Hammond, P. Are You Happy with Your Syllabus? Int. J. of Electrical Engineering Education, 1969, 7, 443-447.

Levien, R.E. The Emerging Technology, McGraw-Hill, N.Y., 1972.

Magin, D.J., Reizes, J.A. and Sivyer, J.A. Fostering Student Initiative in Laboratory Work: A Case Study of an 'Experiment' in Experimental Engineering. Proceedings, Melbourne Conference on Engineering Education, Institution of Engineers Australia, Sydney, 1976, 43-48.

Mayhew, L.B. The Carnegie Commission on Higher Education, Jossey-Bass, San Francisco, 1973.

Reizes, J.A., Holmes, W.N. and Magin, D.J. Use of interactive terminals in computer simulation exercises - some educational developments at the U.N.S.W. Proceedings of the Conference of Institute of Engineers Australia, Sydney, 1974, 138-142.

Svensson, N. Some thoughts on engineering course design and operation. Informal discussion paper (roneo), School of Mechanical and Industrial Engineering, U.N.S.W., 1974.